

WHAT IS CLAIMED IS:

1. An internal combustion engine comprising:

combustion chambers within which fuel is combusted;

an exhaust system through which exhaust flow containing products of combustion is conveyed from the engine, including first and second turbines of a multi-stage turbocharger and a valve for selectively by-passing the exhaust flow around one of the turbines; and

a control system comprising a processor for processing data to develop data for controlling the extent to which the valve selectively by-passes the exhaust flow around the one turbine, wherein

the processor comprises a control strategy a) for processing data values of various parameters to develop a data value representing a desired set-point of operation for the valve corresponding to a desired exhaust by-pass flow around the one turbine, b) for processing the desired set-point data value and a data value correlated with the actual set-point of operation of the valve to develop a set-point error data value for closed-loop control of the actual set-point, c) for selecting a data value of closed-loop gain from a schedule based on a data value of a parameter that characterizes an aspect of engine operation, d) for processing both the selected data value of closed-loop gain and the set-point error data value to create a data value for a closed-loop output, and e) for using the data value for the closed-loop output to create a data value for a final output for forcing the actual set-point to the desired set-point.

2. An engine as set forth in Claim 1 wherein the processor comprises strategy for processing the set-point error data value through both a proportional function and an integral function using a respective data value of closed-loop gain from a schedule for each of the proportional and integral functions and for using respective data values resulting from processing of the set-point error data value by the respective proportional and integral functions to create the data value for the closed-loop output.

3. An engine as set forth in Claim 2 wherein the processor comprises strategy for developing a data value for a feed-forward, open-loop output approximating the desired set-point and for using the feed-forward, open-loop output data value in conjunction with the data value for the closed-loop output to create the data value for the final output.

4. An engine as set forth in Claim 3 wherein the control system comprises a map containing feed-forward set-point data values, each of which is correlated with both a particular data value for engine speed within a range of engine speeds and a particular desired engine fueling within a range of engine fueling, and the processor comprises strategy for selecting one of the feed-forward set-point data values from the map on the basis of a data value indicative of engine speed and of a data value indicative of desired engine fueling developed by the processor, and for then using the one selected feed-forward set-point data value in conjunction with the data value for the closed-loop output to create the data value for the final output.

5. An engine as set forth in Claim 1 wherein the processor comprises strategy for developing a feed-forward data value approximating the desired set-point and for using the feed-forward data value approximating the desired set-point in conjunction with the data value for the closed-loop output to create the data value for the final output.

6. An engine as set forth in Claim 1 wherein the processor comprises strategy for processing a data value indicative of desired engine fueling, a data value indicative of engine speed, a data value indicative of engine temperature, and a data value indicative of barometric pressure to develop the data value representing the desired set-point of operation for the valve corresponding to the desired exhaust by-pass flow around the one turbine.

7. An engine as set forth in Claim 6 wherein the processor comprises strategy for evaluating the data value representing the desired set-point of operation for the valve corresponding to the desired exhaust by-pass flow around the one turbine for compliance with an allowable range defined by a data value for a minimum limit and a data value for a maximum limit.

8. An engine as set forth in Claim 1 wherein the processor comprises strategy for selecting a data value of closed-loop gain from a schedule based on both a data value indicative of desired engine fueling and a data value indicative of engine speed.

9. A control system for controlling the extent to which a valve selectively by-passes exhaust flow around one of two turbines in an engine exhaust system, the control system comprising:

a processor a) for processing data values of various parameters to develop a data value representing a desired set-point of operation for the valve corresponding to a desired exhaust by-pass flow around the one turbine, b) for processing the desired set-point data value and a data value correlated with the actual set-point of operation of the valve to develop a set-point error data value for closed-loop control of the actual set-point, c) for selecting a data value of closed-loop gain from a schedule based on a data value of a parameter that characterizes an aspect of engine operation, d) for processing both the selected data value of closed-loop gain and the set-point error data value to create a data value for a closed-loop output, and e) for using the data value for the closed-loop output to create a data value for a final output for forcing the actual set-point to the desired set-point.

10. A system as set forth in Claim 9 wherein the processor comprises strategy for processing the set-point error data value through both a proportional function and an integral function using a respective data value of closed-loop gain from a schedule for each of the proportional and integral functions and for using respective data values resulting from processing of the set-point error data value by the respective proportional and integral functions to create the data value for the closed-loop output.

11. A system as set forth in Claim 10 wherein the processor comprises strategy for developing a data value for a feed-forward, open-loop output

approximating the desired set-point and for using the feed-forward, open-loop output data value in conjunction with the data value for the closed-loop output to create the data value for the final output.

12. A system as set forth in Claim 11 wherein the system comprises a map containing feed-forward set-point data values, each of which is correlated with both a particular data value for engine speed within a range of engine speeds and a particular desired engine fueling within a range of engine fueling, and the processor comprises strategy for selecting one of the feed-forward set-point data values from the map on the basis of a data value indicative of engine speed and of a data value indicative of desired engine fueling developed by the processor, and for then using the one selected feed-forward set-point data value in conjunction with the data value for the closed-loop output to create the data value for the final output.

13. A system as set forth in Claim 9 wherein the processor comprises strategy for developing a feed-forward data value approximating the desired set-point and for using the feed-forward data value approximating the desired set-point in conjunction with the data value for the closed-loop output to create the data value for the final output.

14. A system as set forth in Claim 9 wherein the processor comprises strategy for processing a data value indicative of desired engine fueling, a data value indicative of engine speed, a data value indicative of engine temperature, and a data value indicative of barometric pressure to develop the

data value representing the desired set-point of operation for the valve corresponding to the desired exhaust by-pass flow around the one turbine.

15. A system as set forth in Claim 9 wherein the processor comprises strategy for evaluating the data value representing the desired set-point of operation for the valve corresponding to the desired exhaust by-pass flow around the one turbine for compliance with an allowable range defined by a data value for a minimum limit and a data value for a maximum limit.

16. A system as set forth in Claim 9 wherein the processor comprises strategy for selecting a data value of closed-loop gain from a schedule based on both a data value indicative of desired engine fueling and a data value indicative of engine speed.

17. A method for controlling the extent to which a valve selectively by-passes exhaust flow around one of two turbines in an engine exhaust system, the method comprising:

a) processing data values of various parameters to develop to develop a data value representing a desired set-point of operation for the valve corresponding to a desired exhaust by-pass flow around the one turbine, b) processing the desired set-point data value and a data value correlated with the actual set-point of operation of the valve to develop a set-point error data value for closed-loop control of the actual set-point, c) selecting a data value of closed-loop gain from a schedule based on a data value of a parameter that characterizes an aspect of engine operation, d) processing both the selected data value of closed-loop gain and the set-point error data value to

create a data value for a closed-loop output, and e) using the data value for the closed-loop output to create a data value for a final output for forcing the actual set-point to the desired set-point.

18. A method as set forth in Claim 17 including processing the set-point error data value through both a proportional function and an integral function using a respective data value of closed-loop gain from a schedule for each of the proportional and integral functions and using respective data values resulting from processing of the set-point error data value by the respective proportional and integral functions to create the data value for the closed-loop output.

19. A method as set forth in Claim 18 including developing a data value for a feed-forward, open-loop output approximating the desired set-point and using the feed-forward, open-loop output data value in conjunction with the data value for the closed-loop output to create the data value for the final output.

20. A method as set forth in Claim 19 including selecting a feed-forward set-point data value from a map containing feed-forward set-point data values, each of which is correlated with both a particular data value for engine speed within a range of engine speeds and a particular desired engine fueling within a range of engine fueling, on the basis of a data value indicative of engine speed and of a data value indicative of desired engine fueling, and then using the selected feed-forward set-point data value in

conjunction with the data value for the closed-loop output to create the data value for the final output.

21. A method as set forth in Claim 17 including developing a feed-forward data value approximating the desired set-point and for using the feed-forward data value approximating the desired set-point in conjunction with the data value for the closed-loop output to create the data value for the final output.

22. A method as set forth in Claim 17 including processing a data value indicative of desired engine fueling, a data value indicative of engine speed, a data value indicative of engine temperature, and a data value indicative of barometric pressure to develop the data value representing the desired set-point of operation for the valve corresponding to the desired exhaust by-pass flow around the one turbine.

23. A method as set forth in Claim 17 including evaluating the data value representing the desired set-point of operation for the valve corresponding to the desired exhaust by-pass flow around the one turbine for compliance with an allowable range defined by a data value for a minimum limit and a data value for a maximum limit.

24. A method as set forth in Claim 17 including selecting a data value of closed-loop gain from a schedule based on both a data value indicative of desired engine fueling and a data value indicative of engine speed.